ECONOMIC EVALUATION OF MILKING SYSTEMS IN ALBERTA

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I. INTRODUCTION

Milking chores on a dairy farm are highly labour intensive. With rising labour costs a trend to modernised and highly mechanised milking systems has become evident. Statistical distribution of producers by herd size in Alberta indicates that the majority of milk is produced by 50-60 cow operations. The type, size and configuration of milking systems in existence in Alberta is undoubtedly influenced by this fact. Although, modern milking parlours are too costly on small farms, they are conducive to milking efficiency on medium and large farms. The most prevalent farm size in a particular production area will also have a strong influence on the selection of milking systems in that area.

A summary of housing and milking systems used in Alberta in 1981 shows that 53.2 per cent of producers are using in-barn (stanchion) milking systems and of that number 55.5 per cent use pipeline. The remaining 46.8 producers use parlor milking systems.

Numerous studies have confirmed that labour cost is the most significant item in milking system cost and in some cases can account for up to 80 per cent of the milking system's total cost. It seems obvious that the best way to minimize milking cost is to reduce labour requirements through adopting a milking system of an efficient size and configuration that meets both the owners needs and herd size. However, it should be realized that increased capital cost will at some point exceed the saving in labour use, resulting in lower cost efficiency. The degree of utilization of a system plays an important role in cost minimization and therefore a system's suitability for a particular herd size is important.

The primary objective of this study was to conduct an economic evaluation of alternative milking technologies commonly used in Alberta, so that a least cost system could be identified for a given herd size or a desired milking time.

More specifically the objectives were:

- to establish the criteria for economic comparison of various systems;
- to determine the labour requirements for alternative systems used in Alberta;
- to establish the capital cost for selected milking systems used in Alberta;
- to identify the least cost system for a large range of herd sizes and/or a given length of a milking shift.

II. METHOD OF ANALYSIS

Economic efficiency was used as the criteria for determining the best systems from selected milking systems commonly used on Alberta dairy farms.

Economic efficiency was defined by cost per unit of output or average cost. It was therefore necessary to develop the unit[1] cost for all milking systems considered in this study.

Milking system, in this context, is defined as the milking procedure and configuration of a milking facility. It does not include cow housing or the milk house. Size and cost of the barn and milk house equipment is determined by the size of herd, while the milking system is a separate entity which can be used for different herd sizes. Although herd size is important, other factors such as labour use and investment cost influence the selection of a milking system.

Selection of a particular milking system also depends on the desired time for one milking shift. For a given herd size an operator would likely decide on different systems if his desired length of milking shift is 1.5 hours instead of 3 hours. To milk 1.5 hours he would need a larger more expensive system than for a 3 hour milking shift. A trade-off between capital and labour would result.

Milking system cost, as an efficiency measure, is composed of labour cost, capital cost and maintenance cost. Classification according to fixed and variable cost is also important. The following diagram shows the cost categories for a milking system.

<table>
<tr><td>CAPITAL COST</td><td>LABOUR COST SET-UP & CLEAN-UP</td><td>LABOUR COST MILKING</td><td>MAINTENANCE COST</td></tr>
<tr><td colspan="2">FIXED COST</td><td colspan="2">VARIABLE COST</td></tr>
</table>

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1 The suitable unit of output volume is, in this particular case, the number of cows handled by a system, although volume of milk could similarly measure the output volume.

Variable costs are directly dependent on the volume of output, that is, the number of cows milked. If the number of cows milked doubles, then the labour cost for milking and maintenance (upkeep) will double. This cannot be said about fixed costs, since the cost of capital (depreciation and interest) and the labour cost for setup and cleanup would be the same regardless of how many cows are milked.

The following formula shows the relationships between variable and fixed costs and the number of cows.

$$C' = F + N \times V$$

Where: C' is total cost
F is fixed cost
V is variable cost
N is number of cows

As the size of herd increases fixed costs will be spread over more cows, thereby reducing the magnitude of the fixed costs. To determine the ultimate measure of efficiency, that is, the average cost per cow, the above equation must be divided by the number of cows.

$$C = \frac{F}{N} + V$$

Where: C is average cost per cow

With a total cost approach, as the size of herd increases total variable costs increase and fixed costs remain constant. With an average cost approach the roles are reversed. Variable costs per cow remain unchanged and fixed costs decrease with herd size. For this reason, it is important to distinguish between the terms total cost and average cost.

The task remains to determine labour and capital costs for each milking system considered in this study. Labour cost is directly related to labour use. The labour requirement for each milking system is determined by the technical efficiency of each system. Technically the most efficient system, that is, the highest throughput of cows per given time,

is not necessarily the most economically efficient. Initial cost and thus the cost of capital will play an important role.

In summary, the method used here to identify the most efficient milking system is a comparison of costs per cow for selected systems most commonly used in Alberta. The actual data used in establishing costs and the assumptions associated with the data are discussed in the following section.

III. DATA AND ASSUMPTIONS

Rather than use the so-called normative or recommended data for selected milking systems, actual time data was collected from farms for this study. It was found that the throughput often recommended differs from actual practice.

The following milking systems were selected for comparison and evaluation.

			# OBSERVED
1.	Stanchion barn - buckets	S3[1]	7
2.	Stanchion barn - pipeline	S5	8
3.	Double 4 herringbone	D4	7
4.	Double 4 herringbone (8 units)	D4-8	9
5.	Double 6 herringbone	D6	4
6.	Double 6 herringbone (12 units)	D6-12	8
7.	Double 8 herringbone	D8	5
8.	Double 8 herringbone (16 units)	D8-16	3
9.	Trigon 12	T12	7
10.	Rotary 14	R14	2
			60

Examples of the general layout or design of these milking systems are shown in Appendix B.

Sixty farms were visited to obtain the information needed for evaluation. An example of the questionnaire is shown in Appendix C.

In order to establish the labour cost for each system good data had to be obtained on the throughput for each system. A stop watch was used to record the setup and cleanup time and the number of men carrying out these tasks. Actual milking time was recorded for three and four repetitions on each milking unit. For instance, for a system with four units, the time for 16 cows being milked was recorded. The time started

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1 These abbreviations are used interchangeably and the numbers represent the number of milking units.

with the first cow entering and finished with the 16th cow departing. Total time (called parlor time) included all activities of milking chores such as washing, installing and removing machine, actual milking, etc. The milking unit activity is basically composed of two parts: actual milking time and machine idle time before the unit is reconnected. Actual milking time is more or less determined biologically, but idle time is influenced by the configuration and size of the milking system and the operator's skill and pace. Given the average time length for milking a cow, the per cent idle time can be calculated by:

$$Ti = 1 - \frac{Tm \times N}{Tp \times U}$$

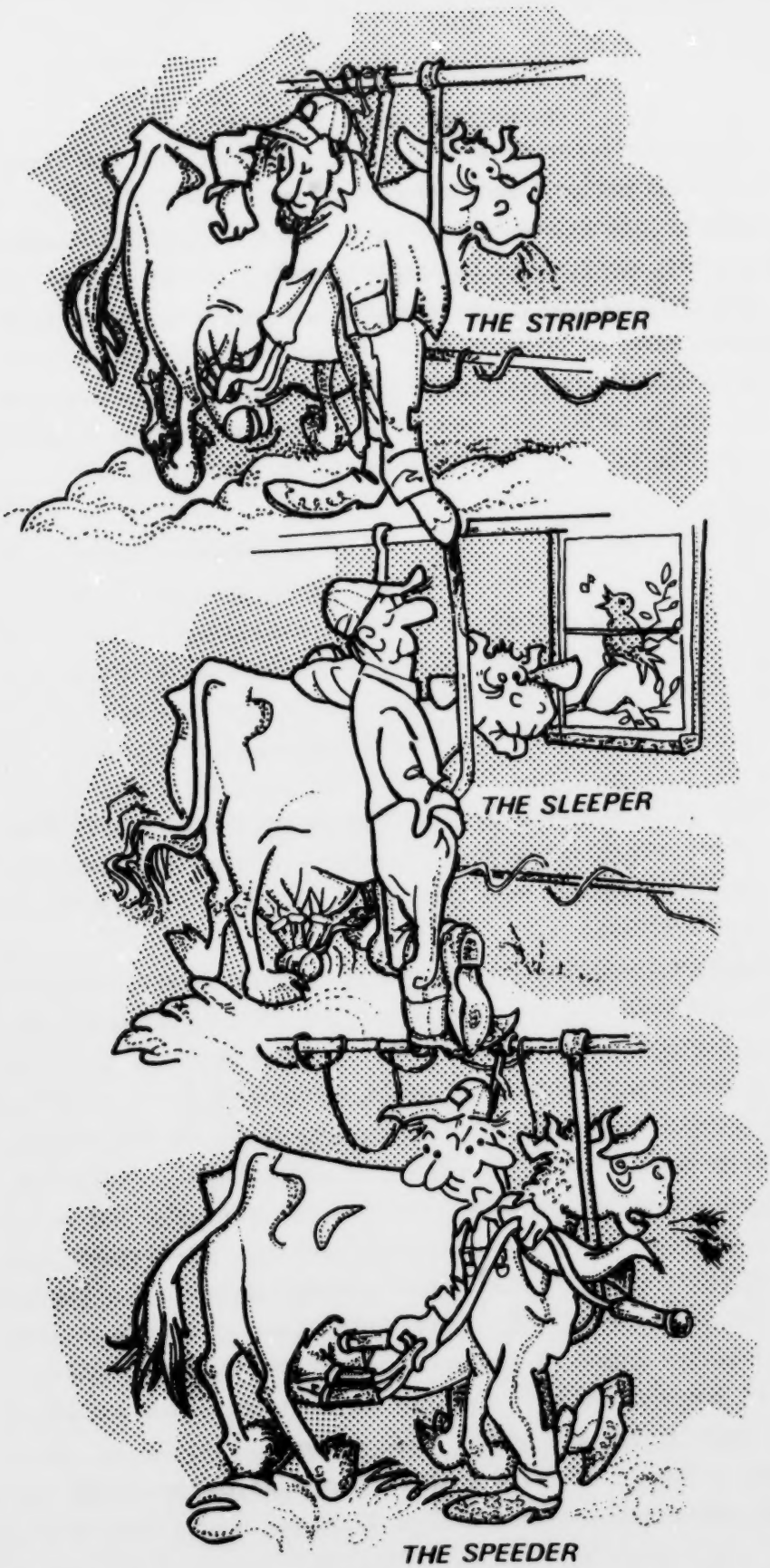
Where:
- Ti - per cent of idle time
- Tm - milking time of a cow (minutes)
- Tp - total parlor time
- U - number of milking units

Sometimes milking chores are carried out by more than one man. In comparing labour requirements for the various milking systems, the work has to be adjusted to a one man operation. Machine idle time was useful in making that adjustment.

Working pace is another factor that influences labour requirements. Adjustments were made for an average working pace, so that the results would show efficiency of the system, not the operator.

Milk production and degree of mechanization could be considered as additional factors affecting the milking time. It is not always true that higher producing cows milk longer or vice versa. A relationship between milk production and milking time was not apparent. While overall the milking time was influenced by the degree of mechanization, it was reflected in incremental capital cost. Higher mechanized systems were using less labour but were more capital intensive. There was no significant difference in degree of mechanization of the systems studied. The occurrence of power gates and automatic take-off units was considered an incremental cost to the cost of the basic system.

Recorded milking time for one shift served as the basis for calculating annual labour cost using a rate of $7.00 per hour. Cost of capital


THE STRIPPER
THE SLEEPER
THE SPEEDER

was calculated from the investment value of each milking system as listed in Table 1. Depreciation was calculated at 5 per cent of building (parlor) value and 10 per cent of equipment value. Interest charges were calculated on average investment value at 12 per cent interest.

Due to the different nature of the in-barn (stanchion) milking systems, capital cost of the S3 and S5 systems is composed of value for the equipment only and not for housing. Some equipment, stanchion stalls and pipeline are expressed on a per cow basis, because they vary as to barn size and herd size. However, the value of milking units and pumps would be the same regardless of herd size, similar to a parlor type facility. This has implication in calculating the total cost since a portion of the capital cost is variable and will depend on the herd size.

TABLE 1: LABOUR AND INVESTMENT REQUIREMENTS FOR MILKING SYSTEMS IN ALBERTA

SYSTEM	SETUP & CLEANUP TIME	MILKING TIME MIN./COW	INVESTMENT[1] BUILDING	EQUIPMENT
S3	32.33	2.69	-	$5400 + 237/Cow
S5	43.33	2.01	-	7200 + 371/Cow
D4	23.77	1.96	$14143	17256
D4-8	26.34	1.67	14143	23637
D6	35.60	1.76	18160	24300
D6-12	37.56	1.17	18160	31534
D8	34.02	1.33	21767	27888
D8-16	37.80	1.07	21767	38508
T12	38.78	0.96	18490	37164
R14	29.77	0.99	23005	39568

[1] Based on Boeckh Building Cost Guide (1984)

Table 2 shows cost equations for all ten systems. Total system cost for any herd size is calculated by multiplying the variable cost by the number of cows and then adding the fixed cost. Average cost is calculated by dividing the equation by the number of cows, i.e. dividing fixed cost by number of cows and adding variable cost.

These equations along with the information from Table 1 are useful in finding the relationships between cost and herd size, and cost and milking shift time shown in the following section and the appendix.

TABLE 2: COST EQUATIONS FOR 10 MILKING SYSTEMS

SYSTEM	FIXED COST	VARIABLE COST
Stanchion - buckets 3	3596.00	283.97 x No. of Cows
Stanchion - pipeline 5	4813.35	253.64 x No. of Cows
H. Double 4	6302.00	192.65 x No. of Cows
H. Double 4-8	7500.50	168.52 x No. of Cows
H. Double 6	8838.50	181.03 x No. of Cows
H. Double 6-12	10304.25	123.87 x No. of Cows
H. Double 8	9664.00	140.79 x No. of Cows
H. Double 8-16	11642.75	118.00 x No. of Cows
Trigon 12	11152.75	104.02 x No. of Cows
Rotary 14	11261.75	110.12 x No. of Cows

IV. ANALYSIS OF RESULTS

There is no one least-cost system. The efficiency of a system varies with the degree of utilization, i.e. the volume of output. A large modern system would be underutilized and costly for a small herd but might be ideal for a large farm. Furthermore technical efficiency[1] is not necessarily indicative of economic efficiency. Although labour use and labour cost are significant in determining a system's efficiency, overall economic efficiency also depends on capital cost.

Results are shown in two ways; a cost comparison for a given length of milking shift and a cost comparison for a given herd size.

Cost Versus Length Of The Milking Shift

The survey showed that the average desired length of a milking shift is 1 3/4 hour. This of course varies with the size of herd. In the analysis we chose to determine milking herd size for a given length of morning and afternoon milking shifts. Once a system's capacity is determined in this way, the resulting costs can be calculated for each system.

Table 3 shows how costs per cow compared for a range of herd sizes utilizing the 10 milking systems studied. A stanchion barn with 3 milking units (S3) can handle only 22 cows when the milking shift is 60 minutes long. The same system can handle 67 cows if the milking time is three hours long. Through greater utilization, annual milking system cost can be reduced from $445.19 per cow with 1 hour milking time to $337.71 with three hours milking time.

It was assumed that 3 hours of milking for one shift would be maximum for a family operation. This is milking time only and excludes the time for setting up and cleaning, as was shown in Table 1. A Trigon system with 12 milking units appears to have the highest capacity of 188

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1 Highest throughput for a given time.

TABLE 3: MILKING SYSTEM COST COMPARISONS WITH TIME RESTRICTIONS

SYSTEM	HERD SIZE	MINUTES /COW	CAPITAL COST	LABOUR COST CLEAN.	LABOUR COST MILK.	UPKEEP COST	TOTAL COST
			1.0 HOUR MILKING				
S3	22.30	4.14	74.74	123.45	229.10	17.90	445.19
S5	29.85	3.46	95.50	123.62	171.18	24.58	414.89
HD4	30.61	2.74	139.73	66.13	166.93	25.72	398.51
HD4-8	35.93	2.40	146.33	62.44	142.23	26.29	377.28
HD6	34.09	2.80	170.33	88.94	149.89	31.14	440.29
HD6-12	51.28	1.94	135.23	65.70	99.64	24.23	324.80
HD8	45.11	2.08	149.99	64.22	113.27	27.52	355.01
HD8-16	56.07	1.74	150.22	57.41	91.13	26.87	325.63
T12	62.50	1.58	125.60	52.84	81.76	22.26	282.47
R14	60.61	1.48	143.98	41.83	84.31	25.81	295.94
			2.0 HOUR MILKING				
S3	44.61	3.41	55.86	61.72	229.10	17.90	364.58
S5	59.70	2.74	76.69	61.81	171.18	24.58	334.27
HD4	61.22	2.35	69.86	33.07	166.93	25.72	295.58
HD4-8	71.86	2.04	73.16	31.22	142.23	26.29	272.90
HD6	68.18	2.28	85.16	44.47	149.89	31.14	310.66
HD6-12	102.56	1.56	67.62	32.85	99.64	24.23	224.34
HD8	90.23	1.71	75.00	32.11	113.27	27.52	247.90
HD8-16	112.15	1.41	75.11	28.71	91.13	26.87	221.81
T12	125.00	1.27	62.80	26.42	81.76	22.26	193.24
R14	121.21	1.24	71.99	20.92	84.31	25.81	203.03
			2.5 HOUR MILKING				
S3	55.76	3.27	52.08	49.38	229.10	17.90	348.46
S5	74.63	2.59	72.93	49.45	171.18	24.58	318.14
HD4	76.53	2.27	55.89	26.45	166.93	25.72	274.99
HD4-8	89.82	1.96	58.53	24.98	142.23	26.29	252.02
HD6	85.23	2.18	68.13	35.57	149.89	31.14	284.74
HD6-12	128.21	1.48	54.09	26.28	99.64	24.23	204.24
HD8	112.78	1.63	60.00	25.69	113.27	27.52	226.48
HD8-16	140.19	1.34	60.09	22.96	91.13	26.87	201.05
T12	156.25	1.21	50.24	21.14	81.76	22.26	175.40
R14	151.52	1.19	57.59	16.73	84.31	25.81	184.45
			3.0 HOUR MILKING				
S3	66.91	3.17	49.56	41.15	229.10	17.90	337.71
S5	89.55	2.49	70.42	41.21	171.18	24.58	307.39
HD4	91.84	2.22	46.58	22.04	166.93	25.72	261.27
HD4-8	107.78	1.91	48.78	20.81	142.23	26.29	238.11
HD6	102.27	2.11	56.78	29.65	149.89	31.14	267.45
HD6-12	153.85	1.43	45.08	21.90	99.64	24.23	190.85
HD8	135.34	1.58	50.00	21.41	113.27	27.52	212.20
HD8-16	168.22	1.29	50.07	19.14	91.13	26.87	187.21
T12	187.50	1.17	41.87	17.61	81.76	22.26	163.50
R14	181.82	1.15	47.99	13.94	84.31	25.81	172.06

cows and a least cost of $163.50 per cow, while the S3 system has lowest capacity and highest cost. Figure 2 shows the efficiency of each system at maximum capacity i.e. a three hour milking limit. It also shows the relationship between labour cost and capital cost.

The importance of system utilization on efficiency is shown in Figure 1. The T12 curve shows a reduction in cost as milking time increases[1] from 1 hour to 3 hours. The T12 system cost is $163.50 for a 188 cow herd but increases to $282.47 for a 63 cow herd. For simplicity, Figure 1 shows the cost trend for 4 systems only. The envelope curve of these 4 cost curves shows the least cost points for the indicated cow numbers. Cost curves for the other 6 systems are shown in Figure 4 in the appendix.

Figure 5 in the appendix summarizes the cost analysis at different milking times. The upper graphs show the cost per cow and the bottom graphs show the herd size with three different milking times for all 10 systems.

Cost Versus Herd Size

Costs were also determined for a given number of cows being handled by a system with no restrictions on milking time. Table 4 shows the cost of each milking system for various herd sizes. The relationship is graphically illustrated in Figure 3 of the appendix. When only 25 cows are being milked the S3 system would have the lowest cost since larger systems would be underutilized and their capital cost would be proportionately higher. For a 25 cow herd size the HD8-16 system would be most costly at $583.71 per cow. Actual milking would take only 27 minutes.

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1 The number of cows handled increases from 63 to 188 as shown in Table 3. Figure 1 is based on Table 3 values.

FIGURE 1:

MILKING SYSTEMS COST FOR VARIOUS HERD SIZES

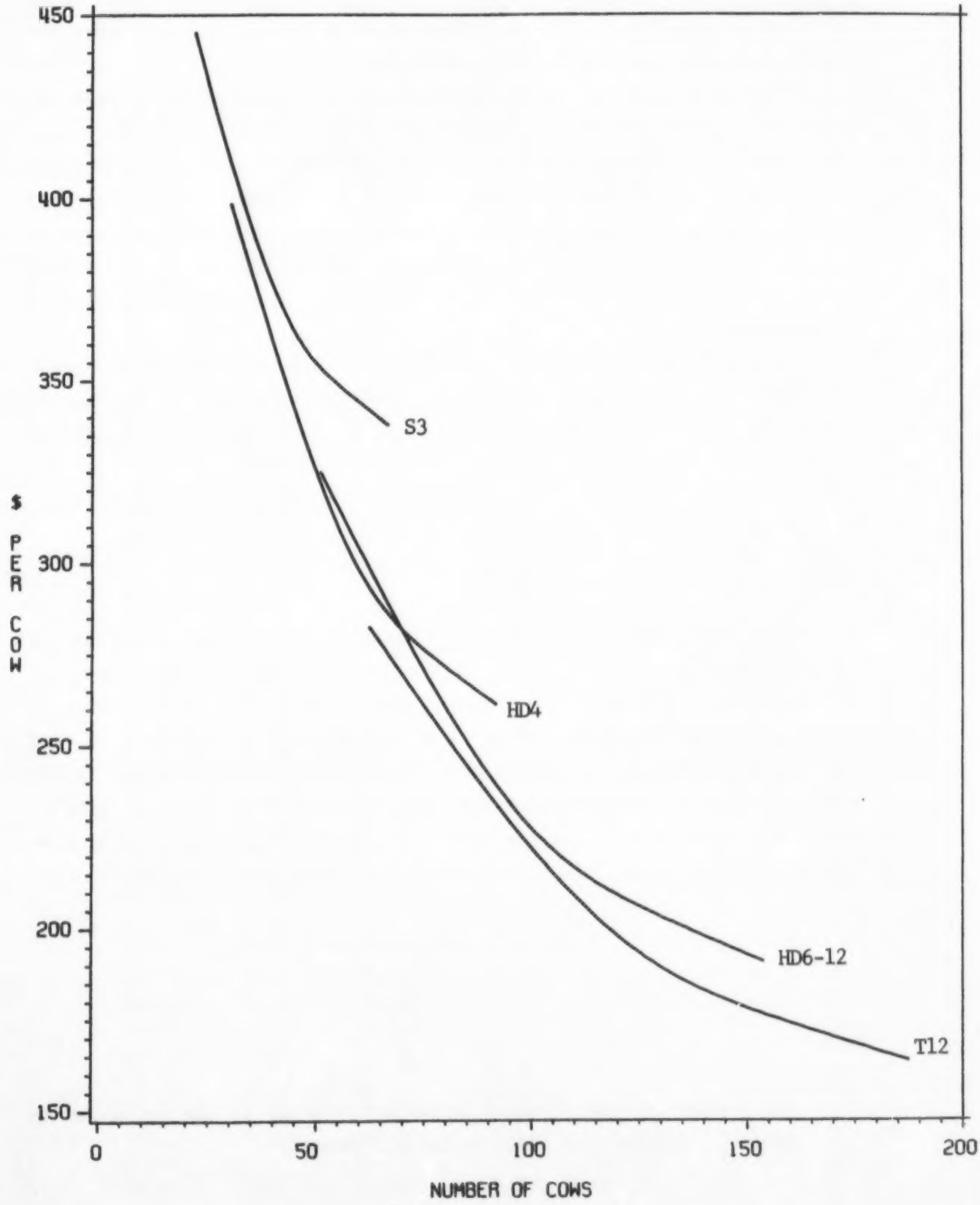
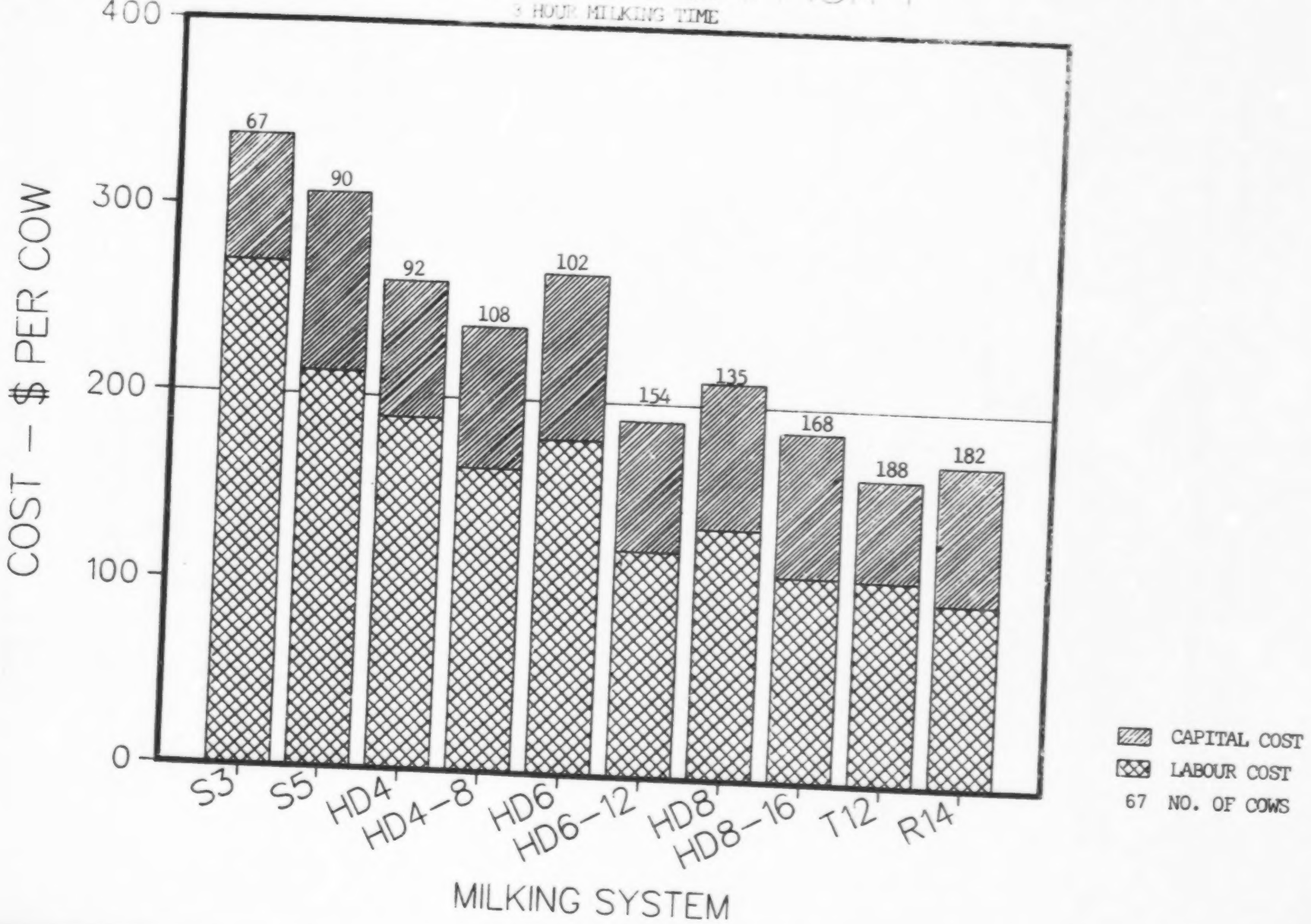


FIGURE 2:

MILKING SYSTEMS COST AT MAXIMUM CAPACITY

3 HOUR MILKING TIME



The graphs in Figure 3 clearly demonstrate that for a 150 cow herd the T12 system is the least cost system and the S3 becomes the most expensive one. As herd size increases the proportion of capital cost decreases, while labour cost changes only slightly. The length of milking shift for the S3 system increases from 1:20 hours for 25 cows to 6:43 hours[1] for 150 cows.

Other tables and figures are included in the appendix, showing various combinations of herd sizes and milking times so that producers can relate the efficiency of each system to their own situation.

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1 This is perhaps beyond the practical range, but it does show that S3 system would not be used for a 150 cow herd and T12 would not be used for a 25 cow herd.

TABLE 4: MILKING SYSTEM COST COMPARISONS WITH NO TIME RESTRICTIONS

SYSTEM	HOURS /SHIFT	MINUTES /COW	CAPITAL COST	LABOUR COST CLEAN.	LABOUR COST MILK.	UPKEEP COST	TOTAL COST
			25 COW HERD				
S3	1.12	3.98	70.67	110.14	229.10	17.90	427.81
S5	0.84	3.74	102.80	147.61	171.18	24.58	446.18
HD4	0.82	2.91	171.10	80.98	166.93	25.72	444.72
HD4-8	0.70	2.72	210.29	89.73	142.23	26.29	468.54
HD6	0.73	3.18	232.26	121.28	149.89	31.14	534.57
HD6-12	0.49	2.75	277.40	134.77	99.64	24.23	536.04
HD8	0.55	2.69	270.67	115.89	113.27	27.52	527.35
HD8-16	0.45	2.58	336.94	128.77	91.13	26.87	583.71
T12	0.40	2.51	314.00	132.11	81.76	22.26	550.13
R14	0.41	2.18	349.05	101.42	84.31	25.81	560.59
			50 COW HERD				
S3	2.24	3.34	53.82	55.07	229.10	17.90	355.89
S5	1.67	2.88	80.34	73.81	171.18	24.58	349.91
HD4	1.63	2.44	85.55	40.49	166.93	25.72	318.69
HD4-8	1.39	2.20	105.14	44.87	142.23	26.29	318.53
HD6	1.47	2.47	116.13	60.64	149.89	31.14	357.80
HD6-12	0.97	1.96	138.70	67.38	99.64	24.23	329.96
HD8	1.11	2.01	135.33	57.95	113.27	27.52	334.07
HD8-16	0.89	1.83	168.47	64.39	91.13	26.87	350.85
T12	0.80	1.74	157.00	66.06	81.76	22.26	327.08
R14	0.83	1.59	174.52	50.71	84.31	25.81	335.36
			75 COW HERD				
S3	3.36	3.12	48.20	36.71	229.10	17.90	331.92
S5	2.51	2.59	72.85	49.20	171.18	24.58	317.82
HD4	2.45	2.28	57.03	26.99	166.93	25.72	276.67
HD4-8	2.09	2.02	70.10	29.91	142.23	26.29	268.52
HD6	2.20	2.23	77.42	40.43	149.89	31.14	298.88
HD6-12	1.46	1.70	92.47	44.92	99.64	24.23	261.26
HD8	1.66	1.78	90.22	38.63	113.27	27.52	269.64
HD8-16	1.34	1.57	112.31	42.92	91.13	26.87	273.24
T12	1.20	1.48	104.67	44.04	81.76	22.26	252.72
R14	1.24	1.39	116.35	33.81	84.31	25.81	260.28
			100 COW HERD				
S3	4.48	3.01	45.40	27.53	229.10	17.90	319.93
S5	3.35	2.44	69.11	36.90	171.18	24.58	301.78
HD4	3.27	2.20	42.77	20.24	166.93	25.72	255.67
HD4-8	2.78	1.93	52.57	22.43	142.23	26.29	243.52
HD6	2.93	2.12	58.07	30.32	149.89	31.14	269.42
HD6-12	1.95	1.57	69.35	33.69	99.64	24.23	226.91
HD8	2.22	1.67	67.67	28.97	113.27	27.52	237.43
HD8-16	1.78	1.45	84.23	32.19	91.13	26.87	234.43
T12	1.60	1.35	78.50	33.03	81.76	22.26	215.55
R14	1.65	1.29	87.26	25.35	84.31	25.81	222.74

TABLE 4 (Continued): MILKING SYSTEM COST COMPARISONS WITH NO TIME RESTRICTIONS

SYSTEM	HOURS /SHIFT	MINUTES /COW	CAPITAL COST	LABOUR COST CLEAN.	LABOUR COST MILK.	UPKEEP COST	TOTAL COST
			150 COW HERD				
S3	6.72	2.91	42.59	18.36	229.10	17.90	307.94
S5	5.03	2.30	65.36	24.60	171.18	24.58	285.73
HD4	4.90	2.12	28.52	13.50	166.93	25.72	234.66
HD4-8	4.17	1.85	35.05	14.96	142.23	26.29	218.52
HD6	4.40	2.00	38.71	20.21	149.89	31.14	239.95
HD6-12	2.92	1.43	46.23	22.46	99.64	24.23	192.57
HD8	3.33	1.56	45.11	19.32	113.27	27.52	205.22
HD8-16	2.68	1.32	56.16	21.46	91.13	26.87	195.62
T12	2.40	1.22	52.33	22.02	81.76	22.26	178.37
R14	2.47	1.19	58.17	16.90	84.31	25.81	185.20
			175 COW HERD				
S3	7.85	2.87	41.79	15.73	229.10	17.90	304.52
S5	5.86	2.26	64.29	21.09	171.18	24.58	281.15
HD4	5.72	2.10	24.44	11.57	166.93	25.72	228.66
HD4-8	4.87	1.82	30.04	12.82	142.23	26.29	211.38
HD6	5.13	1.96	33.18	17.33	149.89	31.14	231.54
HD6-12	3.41	1.40	39.63	19.25	99.64	24.23	182.75
HD8	3.88	1.52	38.67	16.56	113.27	27.52	196.01
HD8-16	3.12	1.29	48.13	18.40	91.13	26.87	184.53
T12	2.80	1.18	44.86	18.87	81.76	22.26	167.75
R14	2.89	1.16	49.86	14.49	84.31	25.81	174.48
			200 COW HERD				
S3	8.97	2.85	41.18	13.77	229.10	17.90	301.95
S5	6.70	2.23	63.49	18.45	171.18	24.58	277.71
HD4	6.53	2.08	21.39	10.12	166.93	25.72	224.16
HD4-8	5.57	1.80	26.29	11.22	142.23	26.29	206.02
HD6	5.87	1.94	29.03	15.16	149.89	31.14	225.22
HD6-12	3.90	1.37	34.68	16.85	99.64	24.23	175.39
HD8	4.43	1.50	33.83	14.49	113.27	27.52	189.11
HD8-16	3.57	1.26	42.12	16.10	91.13	26.87	176.21
T12	3.20	1.15	39.25	16.51	81.76	22.26	159.79
R14	3.30	1.14	43.63	12.68	84.31	25.81	166.43
			250 COW HERD				
S3	11.21	2.82	40.34	11.01	229.10	17.90	298.36
S5	8.37	2.18	62.37	14.76	171.18	24.58	272.89
HD4	8.17	2.06	17.11	8.10	166.93	25.72	217.86
HD4-8	6.96	1.78	21.03	8.97	142.23	26.29	198.52
HD6	7.33	1.90	23.23	12.13	149.89	31.14	216.38
HD6-12	4.87	1.33	27.74	13.48	99.64	24.23	165.09
HD8	5.54	1.47	27.07	11.59	113.27	27.52	179.44
HD8-16	4.46	1.22	33.69	12.88	91.13	26.87	164.57
T12	4.00	1.12	31.40	13.21	81.76	22.26	148.63
R14	4.12	1.11	34.90	10.14	84.31	25.81	155.17

V. SUMMARY AND CONCLUSIONS

Labour can account for as much as 80 per cent of a milking system's total cost. Today's dairy farm operators want to know how labour requirements and labour and capital costs compare for alternative milking systems.

The ten milking systems most commonly used on Alberta dairy farms were compared in this study. The objective was to identify a least cost system for a given herd size or a desired milking time.

Actual milking times were recorded from farm visits and the farm operators were asked how much time they would ideally like to spend setting up, milking and cleaning up each day. Current investment requirements for dairy buildings and equipment were used in a computer program developed to help determine compatible herd sizes and related costs for each of the ten milking systems when the desired milking time per shift ranged from one to three hours.

When three hours was set as a maximum milking time (excluding setting up and cleanup) for a family operation the trigon 12 had the least cost of $164 per cow and could handle 188 cows. The stanchion barn with 3 milking units had a cost of $338 and would handle only 67 cows. The other systems had costs ranging between $310 and $180 and could handle from 90 to 182 cows when three hours was available for each milking shift.

When 67 cows were being milked in a stanchion barn with 3 milking units, labour cost accounted for 82 per cent of the $338 total cost. When a trigon 12 was used to milk 188 cows, labour cost accounted for only 55 per cent of the $164 total milking cost.

The relative costs of the ten milking systems depended on how intensively each system was used and no one least cost system could be found.

APPENDIX A

ADDITIONAL
SYSTEMS COST TABLES
AND FIGURES

TABLE 5:

SYSTEM COST AND MILKING TIME

COST PER COW ($)

SYSTEM \ COWS	25	50	75	100	150	175	200
S3	427.81	355.89	331.92	319.93	307.94	304.52	301.95
S5	446.18	349.91	317.82	301.78	285.73	281.15	277.71
HD4	444.72	318.69	276.67	255.67	234.66	228.66	224.16
HD4-8	468.54	318.53	268.52	243.52	218.52	211.38	206.02
HD6	534.57	357.80	298.88	269.42	239.95	231.54	225.22
HD6-12	536.04	329.96	261.26	226.91	192.57	182.75	175.39
HD8	527.35	334.07	269.64	237.43	205.22	196.01	189.11
HD8-16	583.71	350.85	273.24	234.43	195.62	184.53	176.21
T12	550.13	327.08	252.72	215.55	178.37	167.75	159.79
R14	560.59	335.36	260.28	222.74	185.20	174.48	166.43

% LABOUR COST

S3	79.3	79.8	80.1	80.2	80.4	80.4	80.4
S5	71.5	70.0	69.3	68.9	68.5	68.4	68.3
HD4	55.7	65.1	70.1	73.2	76.9	78.1	78.9
HD4-8	49.5	58.7	64.1	67.6	71.9	73.4	74.5
HD6	50.7	58.8	63.7	66.9	70.9	72.2	73.3
HD6-12	43.7	50.6	55.3	58.8	63.4	65.1	66.4
HD8	43.6	51.3	56.3	59.9	64.6	66.2	78.1
HD8-16	37.7	44.3	49.1	52.6	57.6	59.4	60.9
T12	38.9	45.2	49.8	53.3	58.2	59.9	61.5
R14	33.1	40.3	45.4	49.2	54.6	56.6	58.3

MILKING TIME (HRS.)

S3	1:07	2:14	3:22	4:29	6:43	7:51	8:58
S5	:50	1:40	2:31	3:21	5:02	5:52	6:42
HD4	:49	1:38	2:27	3:16	4:54	5:43	6:32
HD4-8	:42	1:23	2:05	2:47	4:10	4:52	5:34
HD6	:44	1:28	2:12	2:56	4:24	5:08	5:52
HD6-12	:29	:58	1:28	1:57	2:55	3:25	3:54
HD8	:33	1:07	1:40	2:13	3:20	3:53	4:26
HD8-16	:27	:53	1:20	1:47	2:41	3:07	3:34
T12	:24	:48	1:12	1:36	2:24	2:48	3:12
R14	:25	:50	1:14	1:39	2:28	2:53	3:18

FIGURE 3: COSTS AND MILKING TIME FOR VARIOUS HERD SIZES

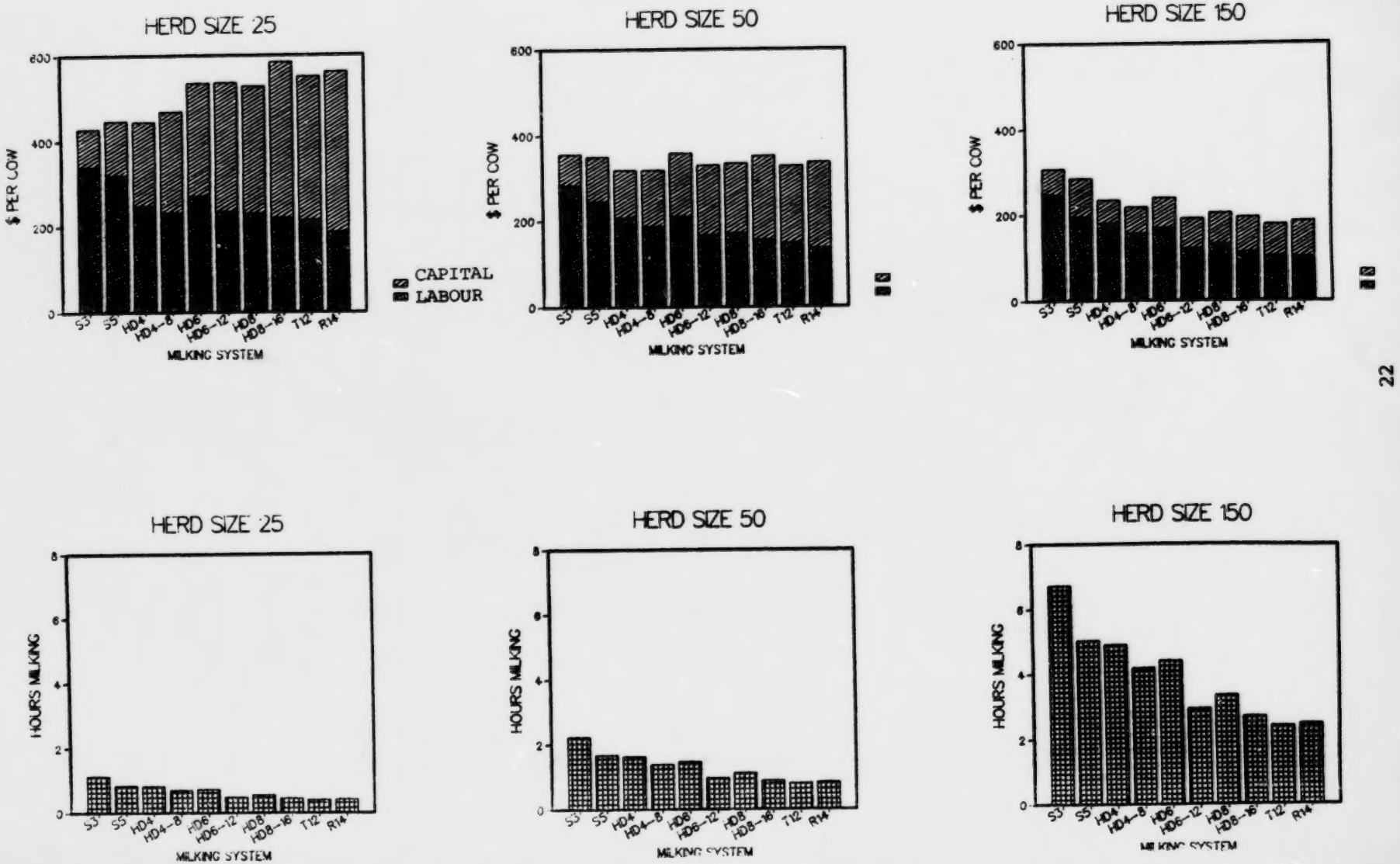


FIGURE 4:

MILKING SYSTEMS COST FOR VARIOUS HERD SIZES

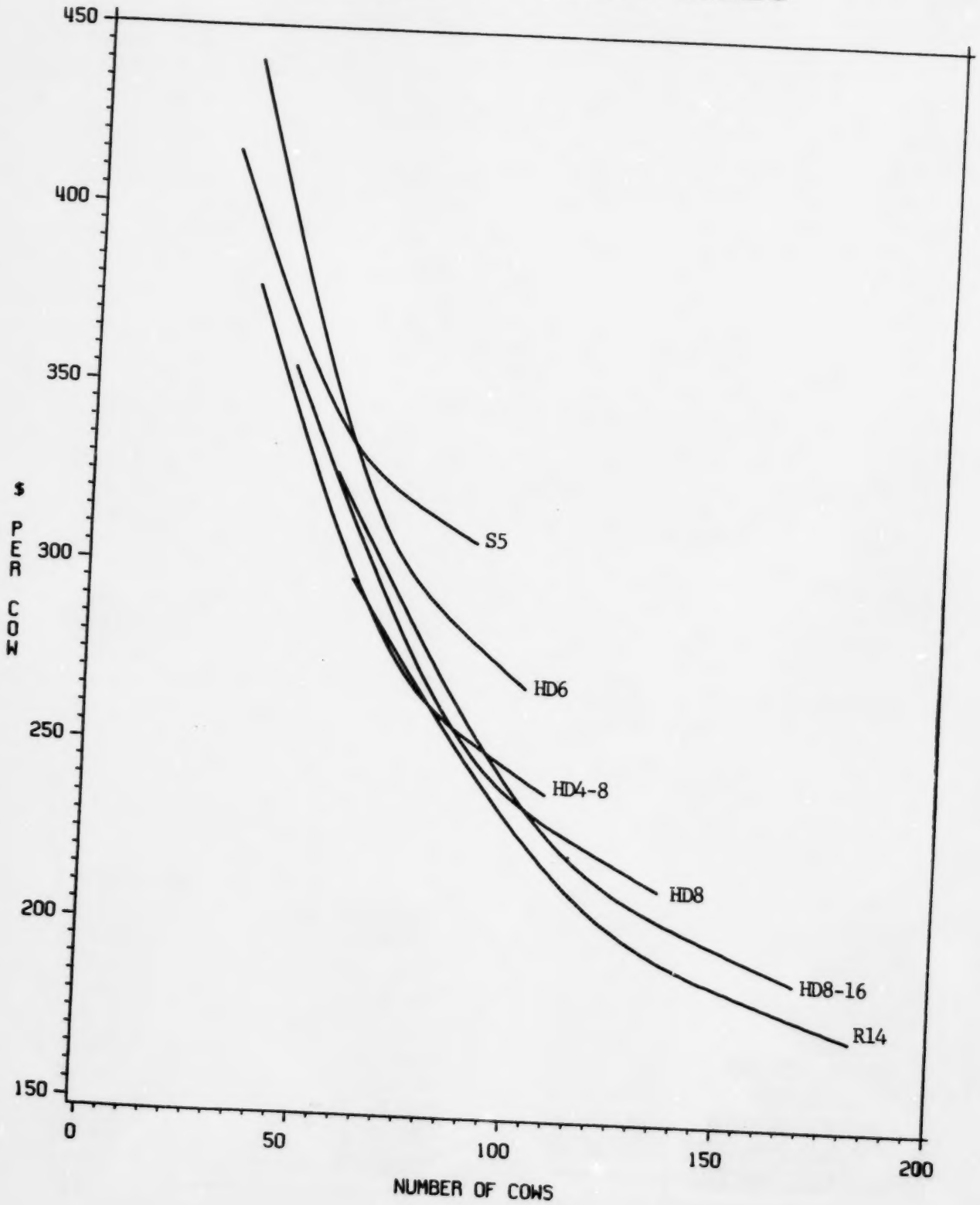


FIGURE 5:

COSTS & CAPACITY FOR VARIOUS MILKING TIMES

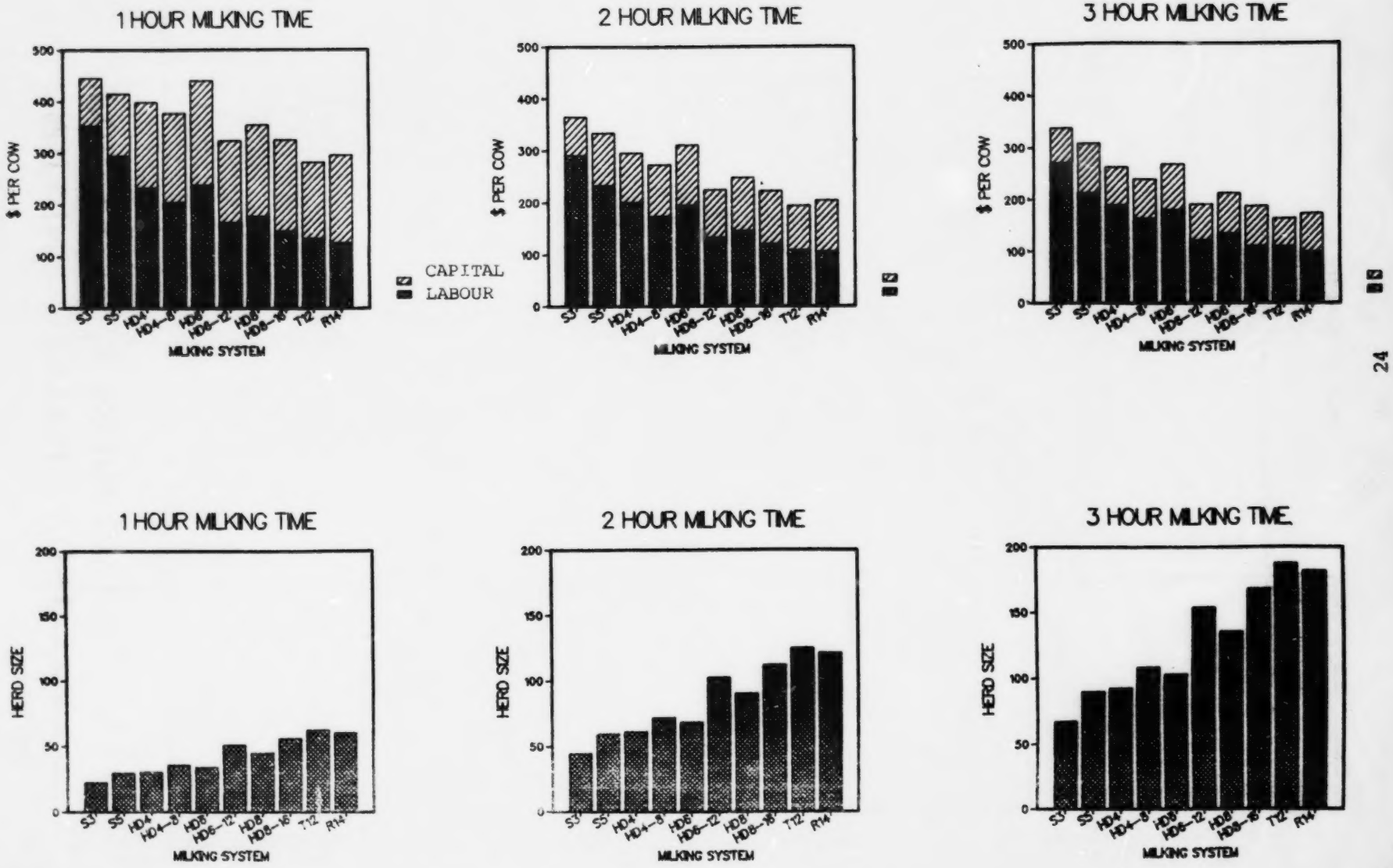
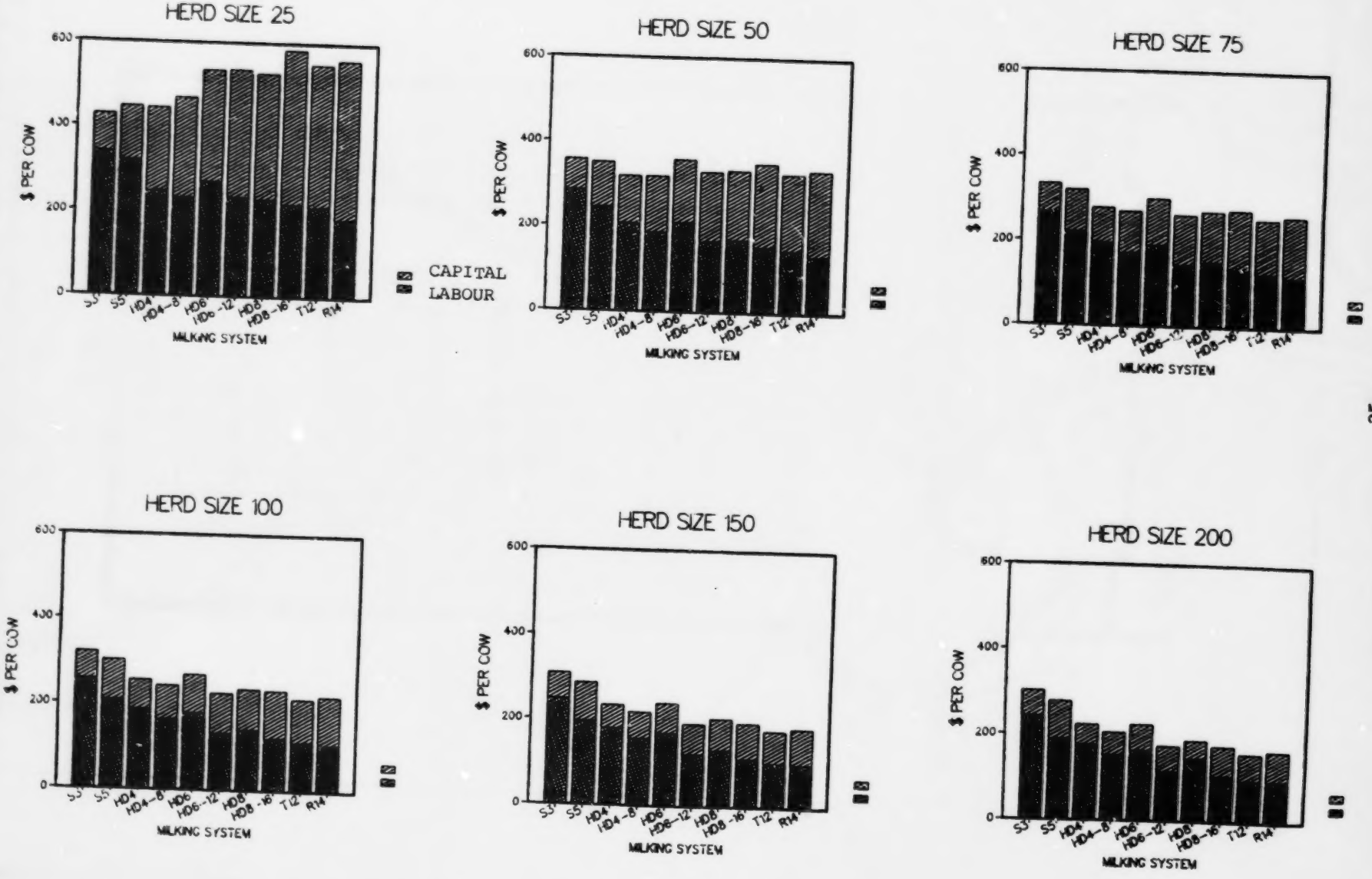
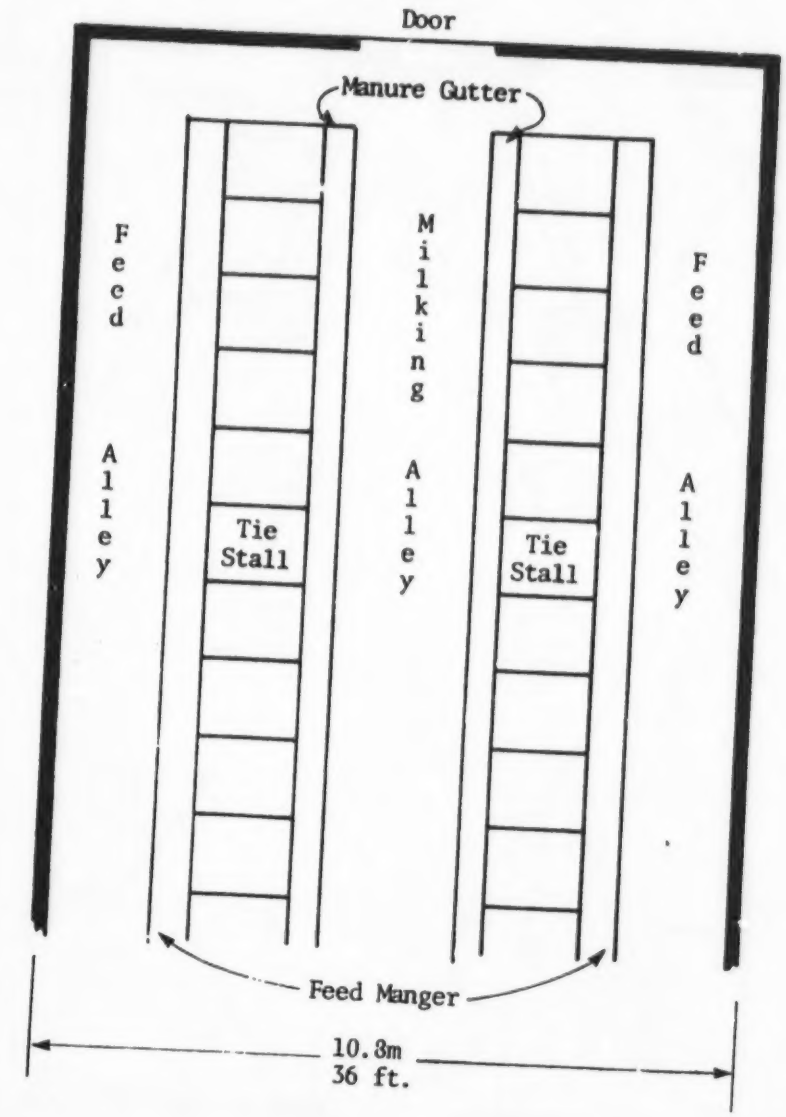


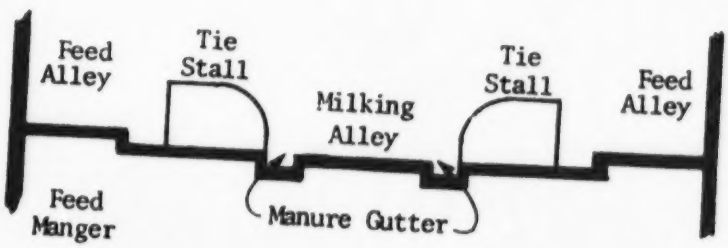
FIGURE 6: MILKING SYSTEMS COST FOR VARIOUS HERD SIZES



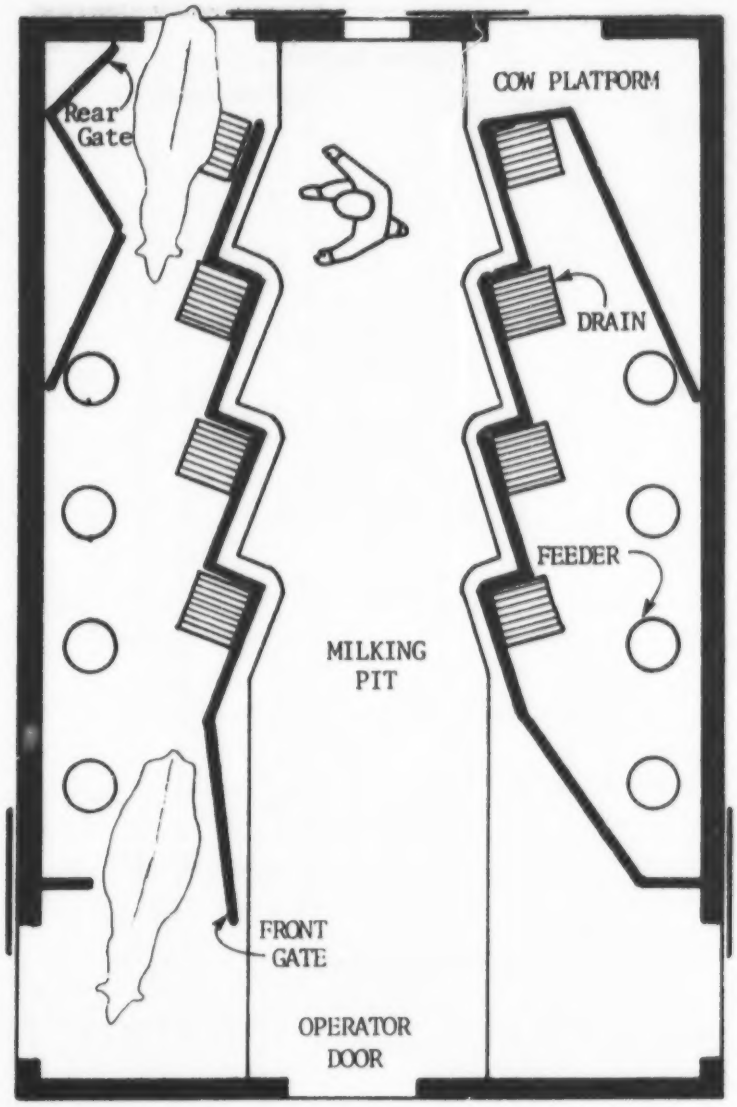
APPENDIX B

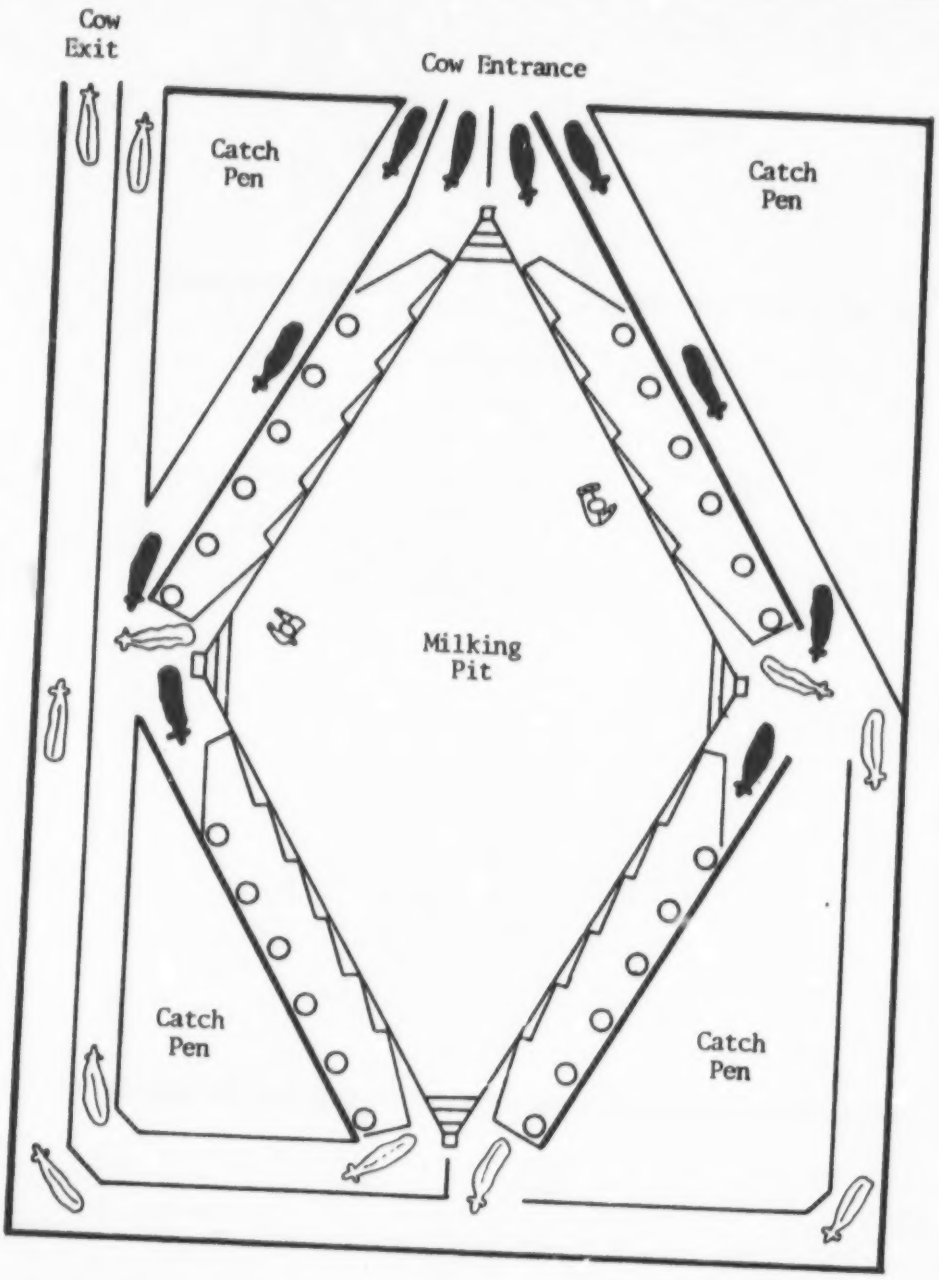
SYSTEMS LAYOUT DESIGNS



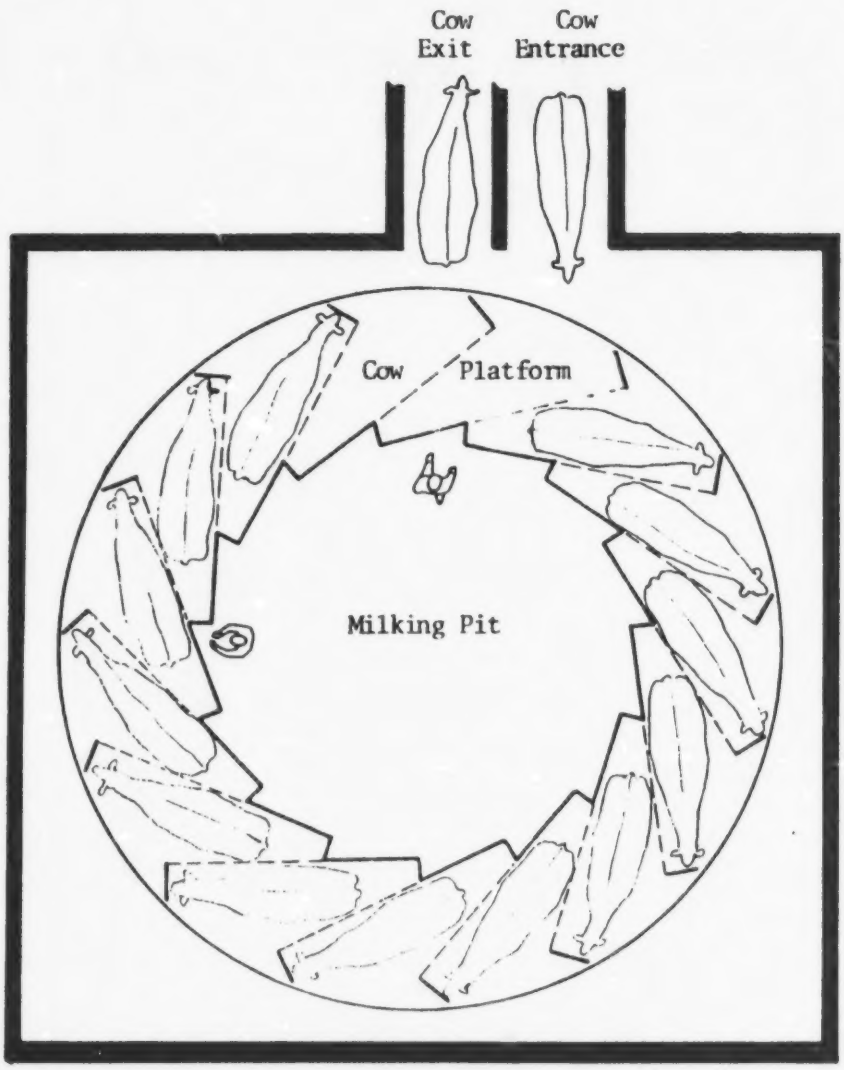


NO. 722-1 SDB-2 FACE OUT STANCHION BARN


COW PLATFORM
Rear Gate
DRAIN
FEEDER
MILKING PIT
FRONT GATE
OPERATOR DOOR
7-8m
22-26 ft.
6m
18-20 ft.



NO. 722-1 MP-8 MILKING PARLOUR POLYGON



On rotary herringbone platforms, the cows enter and exit individually...and are positioned at an angle to the direction of rotation facing the outside of the platform. Their bodies fit together in a fashion similar to conventional herringbone parlours. Thus, the rotary herringbone is smaller in size than a rotary tandem, and the cow's udders are closer together. The milker works from the inside of the platform. These platforms generally rotate continuously, allowing 18-35 seconds per stall with provision for emergency stopping.

APPENDIX C

QUESTIONNAIRE

Milking System Evaluation (data sheet)

Name:_____ Milking System:_____

Herd Size:_____ Date:_____

Mechanization: CG PG FG AW PS SS AMD other_____

		Time (min.)	# of Cows	# of men	Time (min.)
1. Set up time	(AM)				
	(PM)				
2. Parlor time	(AM)				
	(PM)				
3. Machine time	(AM)				
	(PM)				
4. Cleanup time	(AM)				
	(PM)				

AM Cow ID no.																		
AM Production (L)																		
PM Cow ID no.																		
PM Production (L)																		

Desired Milking Time: AM _____ PM _____

Working pace: 1 2 3 4 5

Work satisfaction: 1 2 3 4 5 explain_____

Original price of parlor: $_____ Year:_____

Replacement value: $_____

Annual repair cost: $_____

Insurance: $_____

Comment and observations: